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Duke Energy Carolinas and Progress

EnergyWise for Business Programs Evaluation Report – Final

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Opinion Dynamics

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1. Evaluation Summary

1.1 Program Summary

The Duke Energy Carolinas (DEC) and Duke Energy Progress (DEP) EnergyWise for Business Program is a demand response (DR) and energy efficiency (EE) program that provides small businesses with the opportunity to participate in DR events, earn incentives, and realize additional energy efficiency (EE) benefits. The program was introduced in 2016 and offers participants either a programmable, two-way WiFi Smart Thermostat or a Load Control Switch. Participants can select one of three levels of DR participation—30% cycling, 50% cycling, and 75% cycling—with varying levels of earned incentives based on the selected cycling strategy. Smart thermostat participants who have a heat pump with electric resistance heat strips are also offered the option of participating in winter DR events and can earn additional incentives per season. Customers who opt for the smart thermostat have the ability to manage their thermostat remotely with presets that help them potentially realize energy savings. Duke Energy contracted with Comverge to implement this program.

The program targets small businesses with a qualifying central air conditioning system and a minimum usage of 1,000 kWh per month during the billing months of May through September. By the end of 2016, the program had enrolled a total of 606 customers and 1,202 devices. The program called three summer but no winter DR events in 2016.

1.2 Evaluation Objectives

The 2016 evaluation included a deemed savings review and an engineering-based gross impact analysis to answer the following key research questions:

1. What were the estimated gross demand response impacts from the program in 2016?
2. What were the estimated gross energy efficiency impacts from the program in 2016?

It should be noted that this evaluation did not include a regression-based modeling approach, which is the industry-standard approach to estimating impacts from DR events. As such, the results of this evaluation should be interpreted as directional. The upcoming evaluation of the 2017 EnergyWise for Business Program will include a regression-based model approach to estimating both DR and EE impacts.

1.3 High-Level Findings

Based on our engineering-based impact analysis, the EnergyWise for Business Program fell short of planned savings in 2016, realizing between one-quarter (DEP) and one-third (DEC) of planned DR savings and just above 40% of planned EE savings.

Table 1-1 presents the results of our DR and EE analyses, including ex ante and ex post values for the number of devices, per device savings, and overall impacts, by jurisdiction. The table also presents the resulting realization rates.

Table 1-1.Summary of Gross Impact Analysis

Estimate	DEC			DEP		
	Ex Ante	**Ex Post**	**Realization Rate**	**Ex Ante**	**Ex Post**	**Realization Rate**
Demand Response Impacts						
Average # of Participating Devices[A]	625	442	71%	355	262	74%
Average Per Device kW Savings	3.59	1.54	43%	3.59	1.25	35%
Total Demand Response Savings	**2,244**	**682**	**30%**	**1,274**	**329**	**26%**
Energy Efficiency Impacts						
Number of Enrolled Thermostats[B]	750	692	92%	426	447	105%
Average Per Thermostat kWh Savings	1,450	641	44%	1,450	562	39%
Total Energy Efficiency Savings	**1,087,500**	**443,344**	**41%**	**617,700**	**251,433**	**41%**

[A] Ex post values represent the average number of devices (across the three 2016 DR events) that were enrolled during the event and did not opt out. These are the devices that achieved demand reductions during the 2016 events.
[B] Ex ante and ex post values represent thermostats enrolled at the end of 2016.

Two factors contributed to the shortfall in savings:

1. **Per-unit savings assumptions:** Our deemed savings review found that ex ante per-unit savings were too high, mostly due to an overestimate of the size (tonnage) of the controlled air conditioning units. Since equipment size is directly correlated with savings, the smaller than expected controlled units significantly affected realized EE and DR savings. On the DR side, other contributors to lower than expected per unit savings were a higher than planned adoption of thermostats (which in 2016 were estimated to achieve lower DR savings than switches) and a slight under-enrollment in the more aggressive cycling strategies for DEP.

2. **Enrollment:** By the end of 2016, the program had almost met its planned number of enrolled devices: Enrollment for DEC was 92% of projections while enrollment for DEP exceeded projections (105%). As a result, enrollment assumptions did not significantly contribute to the shortfall in EE savings. Device enrollment did affect DR impacts, however, as some of the devices were not installed until after the summer DR events. As a result, participation levels in the DR events were just short of three-quarters of planned participation.

1.4 Evaluation Recommendations

Because this evaluation was limited to an engineering-based analysis, there is uncertainty about the program impacts achieved in 2016. However, based on our comparison of planning and verified assumptions, we provide the following recommendations for future program planning.

Adopt More Conservative HVAC Average Tonnage Values

The tonnage values tracked in the program participation database suggest that Duke Energy's current planning values are too high. Pending results from the 2017 evaluation, the program may wish to lower its planning values as smaller units, everything else being equal, will achieve lower savings compared to larger units. As a result, an erroneous tonnage assumption might result in the program not achieving its savings goals.

Increase Promotion of Higher Cycling Strategies among Program Enrollees

Participants in DEP seemed to shy away from enrolling in the 75% cycling strategy and opted for strategies that result in lower savings. As such, we encourage Duke Energy to put additional emphasis on 75% cycling when recruiting participants, as it will lead to greater savings. Another alternative would be for Duke Energy to adjust its ex ante assumptions regarding cycling strategies. While this would not increase savings, it would provide more realistic planning assumptions and improve realization rates.

2. Program Description

2.1 Program Design

The Duke Energy Carolinas (DEC) and Duke Energy Progress (DEP) EnergyWise for Business program is a demand response (DR) and energy efficiency (EE) program that provides small businesses with the opportunity to participate in DR events, earn incentives, and realize additional EE benefits. The program was introduced in 2016 and offers participants either a programmable, two-way WiFi Smart Thermostat or a Load Control Switch. Participants can select one of three levels of DR participation—30% cycling, 50% cycling, and 75% cycling—with varying levels of earned incentives based on the selected cycling strategy. Smart Thermostat participants who have a heat pump with electric resistance heat strips are also offered the option of participating in winter DR events and can earn additional incentives per season. Customers who opt for the smart thermostat have the ability to manage their thermostat remotely with presets that help them potentially realize energy savings. Duke Energy contracted with Comverge to implement this program.

The program targets small businesses with a qualifying central air conditioning system and a minimum usage of 1,000 kWh per month during the billing months of May through September.

The program was first implemented by Comverge in the DEC and DEP territories in 2016. The evaluation period considered in this report is January 1, 2016 to December 31, 2016.

2.2 Program Implementation

Duke Energy contracted with Comverge in 2016 to implement the EnergyWise for Business program. Once a customer enrolls in the program, a representative visits the site to install the devices and to show participants how to program their devices and access the web portal. Events are called on weekdays when average temperature criteria are met and a high system peak is projected. Each time an event is scheduled, participants are notified via email and through the web portal. During the event, the devices display a message that an event is in progress. Participants are able to opt out of events at any time before or during the event.

2.3 Program Participation

Based on the program-tracking database, the program distributed 1,202 devices in 2016, associated with 606 unique customer accounts. Customers overwhelmingly opted for Smart Thermostats (95%) over Load Control Switches (5%). The 30% cycling strategy was the most popular among customers, with 63% of devices enrolled into that cycling level. Only 23% of devices were enrolled in the 50% cycling strategy and 14% in the 75% cycling strategy. Table 2-1 provides the distribution of device types and cycling strategies.

Table 2-1. Counts of Enrolled Devices, Device Jurisdiction, Type, and Cycling Strategy

Jurisdiction and Cycling Strategy	Number of Devices			Percentage of Total Devices in Jurisdiction		
	Thermostat	Switch	Total	Thermostat	Switch	Total
DEC						
30%	393	12	405	54%	2%	56%
50%	169	16	185	23%	2%	25%
75%	130	9	139	18%	1%	19%
Jurisdiction Total	692	37	729	95%	5%	100%
DEP						
30%	289	19	308	61%	4%	65%
50%	113	5	118	24%	1%	25%
75%	45	2	47	10%	<1%	10%
Jurisdiction Total	447	26	473	95%	5%	100%
Overall Total	1,139	63	1,202	95%	5%	100%

3. Overview of Evaluation Activities

To address the research objectives for this evaluation, Opinion Dynamics performed a range of data collection and analytic activities. These activities are summarized in this section.

3.1 Program Staff Interviews

We conducted an in-depth interview with the Duke Energy EnergyWise for Business program manager. This interview took place in January 2016. The purpose of this interview was to understand the program's current design and implementation, and to determine the priorities for the impact evaluation.

3.2 Program Materials Review

To inform the subsequent analyses, Opinion Dynamics reviewed program materials, including program design and implementation materials, relevant research reports, and most notably the program-tracking database.

3.3 Engineering-Based Impact Analysis to Determine Ex-Post Savings and Realization Rate

To determine program impacts, the evaluation team used a three-step process: (1) we conducted a deemed savings review; (2) we performed an analysis of the program participation database; and (3) we estimated ex post savings and calculated realization rates.

Step 1: Deemed Savings Review. Opinion Dynamics reviewed inputs and algorithms provided by Duke Energy to document existing (ex ante) assumptions and claimed EE and DR savings. We then performed an engineering analysis using various Technical Reference Manuals (TRMs) and secondary sources to develop verified (ex post) per-unit savings estimates for Smart Thermostats and Load Control Switches. As part of this analysis, we looked up cooling equipment characteristics, based on model numbers, for a sample of 54 participants to update program assumptions about equipment efficiency. We then updated the ex ante savings values based on our engineering analysis and the customer data we received. The deemed savings review, including references to all sources used, is presented in Appendix A.

Step 2: Participation Analysis. The evaluation team reviewed program-tracking data to assess program participation during the evaluation period. This effort included:

- A review of the program participation database to determine the total number of devices and participants, the type of devices installed, and the cycling strategies employed, as well as device installation dates.
- A review of thermostat and switch reports to identify opt-outs.

Step 3: Estimation of Ex Post Savings and Realization Rates. To estimate ex post savings, we applied the ex post per-unit savings values from the deemed savings review (Step 1) with participation counts from the participation analysis (Step 2). We then calculated realization rates for both energy and demand impacts by dividing ex post (evaluated) savings by ex ante (claimed) savings.

4. Gross Impact Evaluation

Our gross impact evaluation included three main analytic steps: (1) a deemed savings review, (2) a participation analysis, and (3) estimation of ex post savings analysis and realization rates for the demand response and energy efficiency components of the program. Figure 4-1 depicts this process.

Figure 4-1. Gross Impact Evaluation Approach

The following subsections describe our approach and the results for each of the three steps.

4.1 Deemed Savings Review

The goal of the deemed savings review was to examine existing program savings values and assumptions and to develop new estimates that the program can use going forward. Our review consisted of several activities:

- We reviewed inputs and algorithms provided by Duke Energy. We also reviewed source documents and program filings to determine existing assumptions about per-device DR and EE savings.
- We reviewed the TRMs for Arkansas, Illinois, Indiana, and the Mid-Atlantic, as well as secondary sources to establish an algorithm for EE savings and to inform assumptions for new per-unit savings estimates for Smart Thermostats and Load Control Switches.
- We used tonnage information from the program-tracking database to update default program assumptions.
- We conducted a look-up of 54 equipment model numbers to develop an estimate of the average efficiency (expressed as the Seasonal Energy Efficiency Ratio [SEER]) of participants' cooling equipment.

Based on the results of these activities, we developed new per-device savings values.

Below, we summarize the inputs for estimating both DR and EE impacts and present the results of the analysis. The full deemed savings review is included in Appendix A.

4.1.1 Demand Response Load Impacts

Our evaluation of the 2016 EnergyWise for Business Program did not include a model-based analysis of DR events.[1] However, one of the key determinants of summer DR event savings is the size (tonnage) of the

[1] Note that a full, model-based DR impact analysis will be performed as part of our 2017 program evaluation.

controlled cooling equipment. Our comparison of program tonnage assumptions with actual tonnage information in the program-tracking database found that the size of participants' cooling equipment is substantially smaller than the program assumption. Everything else being equal, smaller equipment size would lead to smaller per-device DR event savings. To provide updated per device-DR savings, we therefore developed a ratio of actual to assumed equipment size (i.e., average ex post tonnage/average ex ante tonnage). We applied this ratio to the program's ex ante per-device savings assumptions (by device type and cycling strategy), using the following formula:

*Per-Device kW Event Savings = Ex Ante kW * Ex Post Tons/Ex Ante Tons*

Table 4-1 provides the ex ante and ex post tonnage assumptions, by device type and jurisdiction, and the resulting tonnage ratios. Tonnage ratios range from 0.36 for equipment controlled by DEP load control switches to 0.46 for equipment controlled by DEC smart thermostats.

Table 4-1. Tonnage Assumptions for Estimating DR Event Impacts

	Smart Thermostat			Load Control Switch		
		Ex Post			Ex Post	
Parameter	Ex Ante	DEC	DEP	Ex Ante	DEC	DEP
Tonnage	9.62	4.41	4.08	9.62	4.02	3.48
Tonnage Ratio		0.46	0.42		0.42	0.36

[A] In instances where tonnage values were missing from the program participation database (n = 65 devices), the average tonnage for that device and jurisdiction value was imputed.

Table 4-2 shows the program's ex ante per-device savings assumptions for thermostats and switches, by cycling strategy, and the ex post values that result from applying the tonnage ratios to the ex ante values. Given the relatively low tonnage ratios, estimated ex post kW savings are less than half of ex ante savings, across both jurisdictions and device types.

Table 4-2. Assumptions for Estimating Per Device DR Event Savings (kW)

	Smart Thermostat			Load Control Switch		
		Ex Post kW			Ex Post kW	
Cycling Strategy	Ex Ante kW	DEC	DEP	Ex Ante	DEC	DEP
30% Cycling	2.02	0.93	0.86	2.50	1.04	0.90
50% Cycling	3.77	1.73	1.60	4.25	1.78	1.54
75% Cycling	6.27	2.88	2.66	6.75	2.82	2.44

4.1.2 Energy Efficiency Impacts

The program's energy efficiency impacts are associated with smart thermostats only. Duke Energy provided tonnage assumptions as well as per device ex ante savings, but did not provide the algorithm used to develop these savings. We compared the ex ante tonnage assumption with actual tonnages from the program tracking databases and calculated per thermostat ex post savings using the following equation, which is common to most TRMs for thermostat measures:

*kWh savings per thermostat = Tonnage * 12/SEER * EFLHcool * ESF*

Table 4-3 summarizes the ex ante tonnage and per device savings assumptions (provided by Duke Energy) and provides the ex post inputs into the EE savings formula. These inputs include the average equipment tonnage, the average equipment efficiency (SEER), Equivalent Full Load Cooling Hours (EFLHcool), and the Energy Savings Factor (ESF). The deemed savings review memo (Appendix A) provides more detail about these inputs, including the sources of information.

Table 4-3. Assumptions for Estimating EE kWh Impacts

Parameter	Ex Ante Value		Ex Post Value	
	DEC	DEP	DEC	DEP
Tonnage	9.62	9.62	4.41	4.08
SEER	Unknown		11.2	11.8
EFLHcool	Unknown		1,355	1,355
ESF	Unknown		10%	10%
Savings per Thermostat (kWh)	1,450	1,450	641	563

Similar to the per device DR impacts, the greater ex ante tonnage assumption was largely responsible for the difference between ex ante and ex post per-thermostat EE savings. While we do not have ex ante values for SEER, EFLHcool, and ESF, nor the algorithm used, we calculate per-thermostat EE savings of 1,397 kWh (DEC) and 1,326 kWh (DEP) when using the ex post energy savings equation and assumptions but substituting in the ex ante tonnage assumptions. These values are very close to the ex ante EE savings value of 1,450 kWh, so differences in assumptions other than tonnage would be minor.

4.2 Participation Analysis

The second step in the gross impact analysis consisted of an analysis of program enrollment and event participation, based on program tracking data and customer opt out reports. Both are described in this section.

4.2.1 Program Enrollment

According to information provided by Duke Energy, anticipated participation in the program was 1,250 devices for DEC and 710 devices for DEP. The program further assumed that 60% of devices would be thermostats and 40% would be load control switches.

Review of the program tracking data showed a total 2016 enrollment of 729 thermostats and switches in the DEC service territory and 473 thermostats and switches in the DEP service territory, just over half of what was anticipated in the program filings. It should be noted that approximately 34% of these devices were installed after the 2016 summer event season, and therefore were not able to participate in these events. The tracking data also showed a different mix of thermostats and switches from what was anticipated, with fewer customers choosing to install switches than projected.

Table 4-4 provides ex ante and ex post enrollment numbers, by device type and jurisdictionTable 4-4. Projected and Actual Program Enrollment.

Table 4-4. Projected and Actual Program Enrollment (Number of Devices)

Jurisdiction	Device Type	Demand Response			Energy Efficiency		
		# Projected	# Achieved	% Achieved	# Projected	# Achieved	% Achieved
DEC	Thermostat	750	692	92%	750	692	92%
	Switch	500	37	7%	0	0	n/a
	Overall	**1,250**	**729**	**58%**	**750**	**692**	**92%**
DEP	Thermostat	426	447	105%	426	447	105%
	Switch	284	26	9%	0	0	n/a
	Overall	**710**	**473**	**67%**	**426**	**447**	**105%**

To develop expected savings from DR events, the program also projected the share of customers that would select the different cycling strategies. The program projected 50% of enrollment in the 30% cycling strategy, 30% of enrollment in the 50% cycling strategy, and 20% of enrollment in the 75% cycling strategy. These projections were fairly accurate for DEC customers, but DEP customers showed a stronger preference for the 30% cycling strategy at the expense of the 75% cycling strategy. Everything else being equal, a lower cycling percentage will generate lower DR savings. To realize expected savings, the program may therefore need to more strongly promote the higher cycling strategies, particularly among DEP customers.

Table 4-5 provides the projected and actual distributions of enrollment in the three cycling strategies.

Table 4-5. Ex Ante and Ex Post Distribution of Cycling Strategies by Jurisdiction

Jurisdiction	Projected[A]	Actual
30% Cycling Strategy		
DEC	50%	55.6%
DEP		65.1%
50% Cycling Strategy		
DEC	30%	25.4%
DEP		24.9%
75% Cycling Strategy		
DEC	20%	19.1%
DEP		9.9%

[A]Based on 9/19/2014 PowerPoint presentation, entitled “Small Business Demand Response – Evaluation Gate Presentation”

4.2.2 Participation in Demand Response Events

In 2016, the program called three summer DR events, on July 8th, July 14th, and July 27th. The average peak temperature on these three event days was 96 °F.[2] There were no winter events called in 2016.

To assess participation in the three summer DR events, Opinion Dynamics reviewed override reports to assess the number of event opt-outs. These data were then merged with the program tracking data to determine opt-out rates by jurisdiction. As shown in Table 4-6, opt-out rates for events were low, and review of the data does not suggest that opt-outs vary as a function of cycling strategy. It is worth noting that as of the third event on July 28th, only 797 devices had been installed (66% of the total enrolled devices in 2016).

[2] Average peak temperature is based on weather information for Charlotte and Raleigh, NC.

Thus, about a third of 2016 participants were not able to participate in any of the 2016 DR events as they had not yet had their devices installed.

Table 4-6. Device Participation by Event and Jurisdiction

Event Date & Jurisdiction	Enrolled Devices	Device Opt-Outs	Part. Devices	Device Part. Rate
7/8/2016				
DEC	424	1	423	99.8%
DEP	235	1	234	99.6%
Total	659	2	657	99.7%
7/14/2016				
DEC	443	16	427	96.4%
DEP	258	8	250	96.9%
Total	701	24	677	96.6%
7/27/2016				
DEC	495	20	475	96.0%
DEP	302	1	301	99.7%
Total	797	21	776	97.4%

4.3 Estimation of Ex Post Savings

The third step in our gross impact evaluation was to estimate program DR and EE savings using the ex post deemed savings values and information from the program participation database developed in the previous steps. Below, we describe the inputs and algorithms used for the DR and EE ex post savings analyses and present the results.

4.3.1 Demand Response Impacts

For each summer DR event, we estimated kW impacts by multiplying the per-device ex post savings (shown in Table 4-2) by the number of participating devices. Since per unit ex post savings estimates vary by jurisdiction, device type, and cycling strategy, we developed 6 different ex post savings values for each jurisdiction and each event (2 device types x 3 cycling strategies). We then summed over these values to estimate the total event savings by jurisdiction.

Table 4-7 provides the number of participating devices per event, average per device savings (i.e., the weighted average across the three cycling strategies), and overall kW savings. Across both DEC and DEP, both participating devices and savings increased with each event, as a result of the program enrolling new customers as the event season progressed. On average, in DEC savings were 682 kW per event and in DEP savings were 329 kW per event, including savings from both thermostats and switches.

Table 4-7. DR kW Savings by Event

Event Date	DEC Therm.	DEC Switch	DEP Therm.	DEP Switch
7/8/2016				
Number of Participating Devices	401	22	226	8
Average Per-Device kW Savings	1.52	1.86	1.28	1.18
Total Event kW Savings	**609**	**41**	**288**	**9**
7/14/2016				
Number of Participating Devices	403	24	242	8
Average Per-Device kW Savings	1.54	1.79	1.29	1.18
Total Event kW Savings	**619**	**43**	**312**	**9**
7/27/2016				
Number of Participating Devices	450	25	288	13
Average Per-Device kW Savings	1.53	1.83	1.22	1.07
Total Event kW Savings	**687**	**46**	**352**	**14**
Overall Average				
Number of Participating Devices	418	24	252	10
Weighted Average Per-Device kW Savings	1.53	1.83	1.26	1.13
Total Event kW Savings	**638**	**44**	**317**	**11**

Error! Reference source not found. shows the average ex post summer DR event impacts, by jurisdiction, relative to the ex ante values taken from program filings. Overall, the program achieved just under one-quarter of its anticipated DR savings. This shortfall is driven by two key factors: (1) the lower than projected size of participating air conditioning units and (2) the lower than expected enrollment at the time of the 2016 summer events.

The lower per-unit savings realization rate for DEP, compared to DEC, results from the relative under-enrollment in the 75% cycling strategy in that jurisdiction as well as a slightly greater tonnage adjustment compared to DEC.

Table 4-8. Program DR Impacts

Estimate	DEC Ex Ante	DEC Ex Post	DEC Realization Rate	DEP Ex Ante	DEP Ex Post	DEP Realization Rate
Average # of Participating Devices	625	442	71%	355	262	74%
Average Per Device kW Savings[A]	3.59	1.54	43%	3.59	1.25	35%
Total Program Savings	**2,244**	**682**	**30%**	**1,274**	**329**	**26%**

[A]Ex post kW values represent the weighted average of thermostats and switches.

4.3.2 Energy Efficiency Impacts

To estimate EE savings, we multiplied the per thermostat savings (shown in Table 4-3. Assumptions for Estimating EE kWh ImpactsTable 4-3), by the number of enrolled thermostats (shown in Table 2-1). Table 4-9 summarizes ex ante and ex post thermostat counts and per unit savings values and shows the resulting realization rates.

Table 4-9. Program Energy Efficiency Impacts

Estimate	DEC			DEP		
	Ex Ante	Ex Post	Realization Rate	Ex Ante	Ex Post	Realization Rate
Number of Enrolled Thermostats[A]	750	692	92%	426	447	105%
Average Per Thermostat kWh Savings	1,450	641	44%	1,450	562	39%
Total Energy Efficiency Savings	**1,087,500**	**443,344**	**41%**	**617,700**	**251,433**	**41%**

[A] Ex ante and ex post values represent thermostats enrolled at the end of 2016.

Duke Energy achieved just over 40% of its anticipated EE kWh savings. The discrepancy between the ex ante and ex post savings is mainly due to the shortfall in per thermostat savings resulting from the lower than expected size (tonnage) of the controlled air conditioning units.

5. Conclusions and Recommendations

5.1 Conclusions

Based on our engineering-based impact analysis, the EnergyWise for Business Program fell short of planned savings in 2016, realizing between one-quarter (DEP) and one-third (DEC) of planned DR savings and just above 40% of planned EE savings.

Table 5-1 presents the results of our DR and EE analyses, including ex ante and ex post values for the number of devices, per device savings, and overall impacts, by jurisdiction. The table also presents the resulting realization rates.

Table 5-1.Summary of Gross Impact Analysis

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[A] Ex post values represent the average number of devices (across the three 2016 DR events) that were enrolled during the event and did not opt out. These are the devices that achieved demand reductions during the 2016 events.
[B] Ex ante and ex post values represent thermostats enrolled at the end of 2016.

Two factors contributed to the shortfall in savings:

1. **Per-unit savings assumptions:** Our deemed savings review found that ex ante per-unit savings were too high, mostly due to an overestimate of the size (tonnage) of the controlled air conditioning units. Since equipment size is directly correlated with savings, the smaller than expected controlled units significantly affected realized EE and DR savings. On the DR side, other contributors to lower than expected per unit savings were a higher than planned adoption of thermostats (which in 2016 were estimated to achieve lower DR savings than switches) and a slight under-enrollment in the more aggressive cycling strategies for DEP.

2. **Enrollment:** By the end of 2016, the program had almost met its planned number of enrolled devices: Enrollment for DEC was 92% of projections while enrollment for DEP exceeded projections (105%). As a result, enrollment assumptions did not significantly contribute to the shortfall in EE savings. Device enrollment did affect DR impacts, however, as some of the devices were not installed until after the summer DR events. As a result, participation levels in the DR events were just short of three-quarters of planned participation.

5.2 Recommendations

Because this evaluation was limited to an engineering-based analysis, there is uncertainty about the program impacts achieved in 2016. However, based on our comparison of planning and verified assumptions, we provide the following recommendations for future program planning.

Adopt More Conservative HVAC Average Tonnage Values

The tonnage values tracked in the program participation database suggest that Duke Energy's current planning values are too high. Pending results from the 2017 evaluation, the program may wish to lower its planning values as smaller units, everything else being equal, will achieve lower savings compared to larger units. As a result, an erroneous tonnage assumption might result in the program not achieving its savings goals.

Increase Promotion of Higher Cycling Strategies among Program Enrollees

Participants in DEP seemed to shy away from enrolling in the 75% cycling strategy and opted for strategies that result in lower savings. As such, we encourage Duke Energy to put additional emphasis on 75% cycling when recruiting participants, as it will lead to greater savings. Another alternative would be for Duke Energy to adjust its ex ante assumptions regarding cycling strategies. While this would not increase savings, it would provide more realistic planning assumptions and improve realization rates.

6. Summary Form

Duke Energy Carolinas and Progress EnergyWise for Business Program

Completed EMV Fact Sheet

Duke Energy Progress' and Carolinas' EnergyWise for Business Program is a demand response program that provides small businesses with the opportunity to participate in DR events, earn incentives, and realize additional EE benefits. The program offers either a programmable, two-way WiFi Smart Thermostat or a Load Control Switch to customers. Customers can select one of three levels of DR participation: 30% cycling, 50% cycling, and 75% cycling with varying levels of earned incentives based upon the selected cycling strategy. Thermostat participants having a heat pump with electric resistance heat strips are also offered the option of participating in winter DR, and can earn additional incentives per season.

Date	June 12, 2017
Region(s)	Duke Energy Carolinas & Progress
Evaluation Period	1/1/16 through 12/31/16
Total kWh Savings	DEC: 641 kWh DEP: 563 kWh
Coincident kW Impact	DEC : 681 kW DEP : 328 kW
Measure Life	Not evaluated
Net-to-Gross Ratio	Not evaluated
Process Evaluation	No
Previous Evaluation(s)	None

To determine program impacts, the evaluation team used a three-step process: (1) we conducted a deemed savings review; (2) we performed an analysis of the program participation database; and (3) we estimated ex post savings and calculated realization rates.

Step 1: Deemed Savings Review. The evaluation team reviewed the inputs and algorithms used by Duke Energy to estimate ex ante savings. The team adjusted these values based on information from program-tracking data and secondary sources. The full deemed savings review is provided in Appendix A.

Step 2: Participation Analysis. The evaluation team reviewed program-tracking data to assess program participation during the evaluation period. This effort included:

- A review of the program participation database to determine the total number of devices and participants, the type of devices installed, and the cycling strategies employed, as well as device installation dates.
- A review of thermostat and switch log data to determine device operability rates and to identify opt-outs.

Step 3: Estimation of Ex Post Savings and Realization Rates. To estimate ex post savings, we applied the ex post per-unit savings values from the deemed savings review (Step 1) with participation counts from the participation analysis (Step 2). We then calculated realization rates for both energy and demand impacts by dividing ex post (evaluated) savings by ex ante (claimed) savings.

7. DSMore Table

The embedded Excel spreadsheets below contains measure-level inputs for Duke Energy Analytics. Per-measure savings values in the spreadsheet are based on the gross and net impact analysis reported above. Measure life estimates have not been updated as part of this evaluation since it was not part of the evaluation scope.

[DSMore Tables provided in separate files]

Appendix A. Deemed Savings Review

[Deemed Savings Review provided in a separate file]

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2016 Evaluation Report for the Duke Energy Carolinas PowerShare® Program

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EXECUTIVE SUMMARY

This document presents Navigant's evaluation of the Duke Energy Carolinas (DEC) PowerShare® Program for Program Year 2016. The PowerShare Program is a demand response (DR) program offered to commercial and industrial customers that is part of the portfolio of demand side management and energy efficiency (DSM/EE) programs offered by Duke Energy. PowerShare offers participating companies and agencies a financial incentive to reduce their electricity consumption when called upon by Duke Energy.

The DEC program offers customers four options to choose between:

- **Mandatory Curtailment:** In exchange for a monthly availability payment and event performance payments, participants must reduce load during each Mandatory Curtailment Period (MCP) to a contracted firm level.
- **Voluntary Curtailment:** In exchange for an event performance payment, participants may reduce load to a pre-nominated level during Voluntary Curtailment Periods (VCPs).
- **Generator Curtailment:** In exchange for a monthly availability payment and event performance payments, participants must transfer load from a Duke Energy source to a private generation source during Generator Curtailment Periods (GCPs).
- **CallOption Curtailment:** In exchange for a monthly availability payment and event performance payments, participants must reduce load during Emergency or Economic Curtailment periods to a contracted firm level. There are currently no DEC customers enrolled in the CallOption PowerShare option and so this option is not addressed in this report.

No Voluntary curtailment events were called in the period of analysis.

Evaluation Objectives

The research objectives of this evaluation are as follows:

1. Validate Duke Energy's DR baseline approach and calculations, as well as the monthly and seasonal capability calculations.
2. Audit the hourly kW DR event load shed for participating customers by replicating the Schneider Electric Energy Profiler Online™ (EPO) methods used to calculate the energy (kWh) and demand (kW) impacts that are used to determine settlement payments.

To complete the first objective, Navigant conducted a detailed audit of the SAS code used by Duke Energy to determine participant baselines and monthly and seasonal capability. To complete the second objective, Navigant replicated the EPO energy and demand calculations used by Duke Energy to determine settlement payments.

Key Findings

This section presents Navigant's key evaluation findings for the two principal evaluation objectives:

Duke Energy Baseline SAS Code Audit

Code performing correctly. Navigant performed a detailed audit of the SAS code used by Duke Energy to calculate settlement baselines, as well as monthly and seasonal capabilities, and found that the code was performing correctly. Navigant's approach to reviewing the SAS code was to document the flow of the datasets with high-level annotations along with making notes of the datasets utilized in each SAS script. These notes provide Duke Energy with a basis for improving the flow of the code and help identify datasets that can be deleted after each step to improve data management.

Opportunities for improved functionality. Navigant identified several opportunities to improve the functionality of the SAS code along with organizational suggestions that may reduce the potential for errors. Additionally, there is unnecessary code that has been used to explore alternative baseline calculations that can be removed from the code. Navigant's detailed recommendations provide actionable revisions to the SAS code that will simplify and consolidate the analysis. Follow-up discussions with Duke Energy indicate the unnecessary code, which is represented as comments, is being reviewed and either eliminated or simplified.

Verification and Validation of Settlement Energy and Demand Calculations

Settlement calculations verified as correct. EPO is used by Duke Energy to determine the energy (kWh) and capacity (kW) values that are the basis for calculating monthly settlement amounts. Navigant replicated the calculations for all of the participants in the period from June through September of 2016**.** A comparison of Navigant's replicated calculations with the output of EPO revealed no deviations beyond what could be expected as a result of rounding error, meaning that Duke Energy's estimates are accurate per the settlement algorithms defined by the program literature. A summary of the validation results, by option and credit type, may be found in Table 1 below.

Table 1: Verification of EPO Calculations

Program Option	Credit Type	Customers	Unique Accounts	# of EPO Results Replicated[a]	Average % Absolute Error[b]
Mandatory Curtailment	Energy	93	168	663	0.00%
Mandatory Curtailment	Capacity	93	168	663	0.01%
Generator Curtailment	Energy	9	12	48	0.00%
Generator Curtailment	Capacity	9	12	48	0.01%

a. The number of calculations reproduced by Navigant for this analysis. For energy there is one credit calculated per participating account per event. For capacity there is one credit calculated per participating account per month. The period of analysis for this evaluation included four months and four curtailment events.

b. The absolute error represents the difference between Navigant's replicated settlement results and the EPO estimates used by Duke Energy. The near-zero error demonstrates that Navigant was able to replicate settlement calculations using the algorithms provided by Duke Energy.

Source: EPO Settlement Data and Navigant analysis

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1. INTRODUCTION

This document presents Navigant's evaluation for the Duke Energy Carolinas (DEC) PowerShare Program for Program Year 2016. The PowerShare Program is a demand response program offered to commercial and industrial customers that is part of the portfolio of demand side management and energy efficiency (DSM/EE) programs offered by Duke Energy. PowerShare offers participating customers a financial incentive to reduce their electricity consumption when called upon by Duke Energy.

1.1 Program Overview

The customer contracts for DEC's PowerShare Program commence on the first day of the month and the initial contract term is three years. Customers can sign up for PowerShare at any time during the year if their DSM rider status is either Opted-In or Not Opted-Out (Opt-In then required to join the program). If they are Opted-Out, they must wait until one of the two Opt-In/Opt-Out election windows during the year (November-December or first week in March) is open in order to change their designation to Opt-In.

The DEC program offers customers four options to choose between: Mandatory Curtailment, Voluntary Curtailment, Generator Curtailment, and CallOption. There are currently no DEC customers enrolled in the CallOption PowerShare option; therefore, this option is not addressed in this report. No Voluntary curtailment events were called in the period of analysis. Curtailment options are defined as follows:

- **Mandatory Curtailment:** In exchange for a monthly availability payment and event performance payments, participants must reduce load during each Mandatory Curtailment Period (MCP) to a contracted firm level.
- **Voluntary Curtailment:** In exchange for an event performance payment, participants may reduce load to a pre-nominated level during Voluntary Curtailment Periods (VCPs).
- **Generator Curtailment:** In exchange for a monthly availability payment and event performance payments, participants must transfer load from a Duke Energy source to a private generation source during Generator Curtailment Periods (GCPs).

The PowerShare Program is designed to encourage the participating organizations to reduce their electricity consumption for up to 100 hours each year on system peak days. Duke Energy contracts with Schneider Electric to calculate monthly customer settlements for the PowerShare Program. Schneider Electric is a specialized firm providing services in energy management and automation. The PowerShare settlements are calculated with the use of Schneider Electric's Energy Profiler Online (EPO), a third-party hosted software application designed to assist utilities with energy data analysis. EPO uses participant interval data, Duke Energy-generated participant baselines and a set of program option-specific calculations to determine the event energy (kWh) and monthly capacity (kW) values that determine participant settlement payments.

1.2 Evaluation Objectives

The research objectives of this evaluation are:

1. Validate the detailed DR baseline approach and calculations, as well as the seasonal and monthly capability calculations performed by Duke Energy.

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2. Audit the hourly kW DR event load shed for participating customers by replicating the Schneider Electric Energy Profiler Online™ (EPO) methods used to calculate the energy (kWh) and demand (kW) impacts that are used to determine settlement payments.

1.2.1 Validate Detailed DR Baseline Approach and Capability Calculations

To complete the first objective, Navigant conducted a detailed audit of the SAS code used by Duke Energy to determine participant baselines, monthly, and seasonal capabilities.

As established in a series of conversations with Duke Energy in August of 2016, Navigant was tasked with conducting a detailed review of the SAS code used by Duke Energy to determine participant baselines (sometimes referred to as "pro forma") and the manner in which these were used to determine monthly capability.

As specified by Duke Energy, this review focused on two key issues:

a. Identifying technical flaws in the code (e.g., code that fails to do what the author intends it to do, or else does more than it is intended to do).
b. Ensuring that the in-line commenting is sufficiently clear and complete that the code is useable by a competent SAS programmer with experience and understanding of demand response programs.

Navigant did not execute the code, however the Navigant analyst performed a detailed assessment of output extracts from each section of the code, and coordinated closely with the Duke Energy SAS code author throughout the review process.

1.2.2 Verify Energy and Demand Calculations Used for Settlement

To complete the second objective, Navigant replicated the energy and demand calculations used by Duke Energy to determine settlement payments and compared these with the energy and demand values reported in the program's operational tracking database for the calculation of settlement payments.

The energy and demand calculations used by Duke Energy to determine settlement payments are generated by the Energy Profiler Online (EPO) tool, a Schneider Electric software product. Schneider Electric's EPO outputs a settlement report for each participant settlement (monthly capacity and event energy settlements). Each report contains the data (including the Duke Energy baseline and the participant actuals) used and the arithmetic applied to calculate the settlement payment.

To fulfill this task, Duke Energy directed Navigant to replicate the settlement arithmetic for the population of Schneider Electric reports for all PowerShare participants from June through September of 2016. The purpose of this replication was effectively to audit the process and ensure that all algorithms were applied as specified in the program literature.

1.3 Program Rules

This sub-section provides some additional detail regarding the program rules, specifically, those rules that define how much DR participants are required to provide, and a summary of the participant credits.

This information is a summary of the DEC PowerShare Program brochure to which interested readers should refer for additional detail.[1] This section does not address the CallOption PowerShare option because, although it is available to DEC customers, there are currently no DEC customers enrolled in that option.

As noted above, there are four PowerShare program options in DEC territory, but one (CallOption) has no participants enrolled, and another (Voluntary) had no events during the summer of 2016. Each of these options is associated with one of two compliance plans:

- Fixed. A “Fixed” compliance plan is a “down by” requirement (i.e., when called participants must reduce demand by X kW).
- Firm. A “Firm” compliance plan is a “down to” requirement (i.e., when called participants must reduce demand to X kW).

The Mandatory, Voluntary and CallOption options operate under the “Firm” compliance plan, whereas the Generator option operates under the “Fixed” compliance plan.

All options require participants to commit to curtailing a minimum of 100kW per event.

Table 2, below, presents some additional detail regarding the program rules for the three PowerShare options in DEC territory with enrolled participants. Note that participants enrolled in the Mandatory option may also enroll for the Voluntary option.

[1] Duke Energy Carolinas, *PowerShare Carolinas* (Program Brochure), Accessed November 2016 https://www.duke-energy.com/business/products/powershare

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Table 2: Detailed PowerShare Option Rules

	Mandatory	Voluntary	Generator
Eligibility	Available to customers served on rate schedules LGS, I, OPT, MP, and HP.	Available to customers served on rate schedules LGS, I, OPT, and MP.	Available to customers served on rate schedules LGS, I, OPT, and MP.
Notice	30 Minutes	Day ahead	15 Minutes
Curtailment Frequency and Timing	Curtailment may occur at any time, but may last no more than 10 hours per event. A maximum of 100 hours of curtailment may be called per year.	Curtailment may occur at any time, length of curtailment periods and number of curtailment periods are at Duke Energy's discretion, but event-by-event participation is entirely voluntary.	Curtailment may occur at any time, but may last no more than 10 hours per event. A maximum of 100 hours of curtailment may be called per year.
Energy Payment	***Event Energy Credits.*** Energy eligible for credit is calculated as the difference between Forecasted Demand and Firm Demand during the curtailment period times. Participants earn $0.1 of credit per kWh curtailed.	***Event Energy Credits.*** Energy eligible for credit is calculated as the difference between Forecasted Demand and Firm Demand during the curtailment period times. Energy Credit payments for energy curtailed are market-based. Participants are eligible for payment only when 50% or more of their day-ahead nominated energy is curtailed during a Curtailment Period.	***Event Energy Credits.*** Energy eligible for credit is the amount of energy transferred to the generator during Curtailment Period times and monthly tests. Participants earn $0.1 of credit per kWh curtailed.
Capacity Payment	***Capacity Credits.*** Capacity eligible for credit (i.e., "Effective Curtailable Demand") is calculated by averaging the actual hourly load less the Firm Demand (the amount participant must curtail to) over the Exposure Period (hours of overall peak demand during which curtailment is most likely). Customer credits are $3.5/kW of Effective Curtailable Demand per month.	None	***Capacity Credits.*** The capacity eligible for credit is determined based on the average capacity generated during all Curtailment Periods and monthly tests, and is capped at participant Maximum Curtailable Demand. Eligible capacity is calculated monthly, and participants are paid $3.5/kW.
Penalty	Failure to reduce to Firm Demand levels incurs a penalty of $2/kWh for every kWh consumed above the Firm Demand level.	None	Failure to reduce by more than 50% of Maximum Curtailable Demand results in an energy charge of $2/kWh for energy shortfall below 50% of Maximum Curtailable Demand.

Source: Duke Energy

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2. EVALUATION METHODS

This section of the PowerShare evaluation outlines the methods employed by the evaluation team to complete the evaluation.

This section is divided into two sub-sections:

- **Duke Energy Baseline SAS Code Audit.** This sub-section describes Navigant's approach to auditing the SAS code developed by Duke Energy to estimate participant baselines and calculate capabilities.
- **Replication of EPO Calculations.** This sub-section describes the approach and data used to replicate the EPO calculations that deliver the energy and demand used by Duke Energy to determine settlement payments.

2.1 Duke Energy Baseline SAS Code Audit

Navigant's approach to reviewing the SAS code was to document the flow of the datasets with high-level annotations along with making notes of the datasets utilized in each SAS script. The notes taken on the datasets utilized in each script were provided to Duke Energy in an Excel workbook. These technical notes are intended to provide Duke Energy with a basis for improving the flow of the code and to help identify datasets that can be deleted after each step to improve data management. The high-level annotations are included in Navigant's documentation of the SAS code process flow, which may be found in Appendix A of this report.

2.2 Replication of EPO Calculations

This sub-section describes the approach and data used by Navigant to replicate the EPO calculations for energy and demand used by Duke Energy to determine settlement payments.

It is divided in two parts:

- **Input Data.** This part lists the key data and documents used as inputs for this analysis.
- **Description of EPO Calculations.** This part provides the algebraic descriptions of the calculations replicated by Navigant.

2.2.1 Input Data

Navigant used the following key input data and documents to replicate the EPO settlement calculations:

1. EPO settlement results data
2. DEC PowerShare participants' interval consumption data
3. DEC PowerShare Program brochure[2]

[2] The DEC PowerShare Program brochure can be found at https://www.duke-energy.com/business/products/powershare

4. The Schneider Electric summary of data required to complete settlement algorithms, provided to Navigant by Duke Energy.
5. PowerShare program guidelines, provided to Navigant by Duke Energy.

2.2.2 Description of EPO Calculations

This section summarizes Navigant's replication of the EPO calculations that estimate the energy and demand values used by Duke Energy to determine settlement. There are several key terms that are worth formally defining in order to clarify their use in equations that follow. These terms are:

- **Exposure Period**: Hours of overall peak demand which curtailment is most likely. Actual curtailment events can occur outside of seasonal exposure period.
- **Forecasted Demand**: Estimated hourly demand a customer would normally exhibit in absence of curtailment.
- **Firm Demand**: Portion of demand not subject to interruption (curtailment).
- **Maximum Curtailable Demand**: Maximum amount of load transferred from the utility source to the generator during Curtailment Periods and monthly tests that is eligible for incentives.

Navigant applied the equations in this section to the interval consumption data resulting in the relevant energy or capacity credits. Navigant then compared the calculated credits to the EPO settlement data and verified that the results were essentially identical for each calculation.[3]

Event Energy Credits (Applies to Mandatory and Voluntary Participants)

$$CE = \sum_h [MAX\left(F_h - M\right) - MAX\left(0, A_h - M\right)]$$

Where:

CE	=	Curtailed energy,
F_h	=	Forecasted demand in half-hour h within the curtailment period,
M	=	Firm demand,
A	=	Actual demand in half-hour h

And where $F_h > A_h$, and zero otherwise.[4]

Monthly Capacity Credits (Apply Only to Mandatory Participants)

$$ECD = A_i - M$$

Where:

A_i	=	Average demand for month i during the exposure period,
M	=	Firm demand,
ECD	=	Effective Curtailment Demand

[3] Some small insignificant differences in individual calculations were found due to rounding effects.
[4] NB Navigant verified only the energy curtailed amounts that contributed to participant energy credit calculation. Verification of energy use during the curtailment period that was subject to penalty payments was not verified.

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Event Energy Credits (Applies Only to Generator Participants)

$$GE = \sum_{h}(G_h)$$

Where:

GE	=	Generated energy eligible for credit,
G_h	=	Energy generated in half hour h

Generated energy above the maximum curtailable demand for any half hour is not eligible.

Monthly Capacity Credits (Applies Only to Generator Participants)

$$AMGC = \sum_{e \in m}(GE_e) / \sum_{e \in m}(H_e)$$

Where:

AMGC	=	Average monthly generated capacity,
Ge_e	=	Generated energy eligible for credit in event e,
H_e	=	Number of half-hour intervals in event e
$e \in m$	=	Events occurring during month m

Events are defined as all generator curtailment events and tests in a given month

3. EVALUATION FINDINGS AND RESULTS

This section describes the findings and results of Navigant's evaluation. It is divided into two sections:

- **Duke Energy Baseline SAS Code Audit.** This section describes Navigant's findings and recommendations based on our audit of the Duke Energy SAS code.
- **PowerShare Impacts and Findings from Navigant's Replication of EPO Calculations.** This section describes Navigant's findings based on our analysis of the program tracking database[5] and the replication of the EPO calculations that deliver the energy and demand impacts used by Duke Energy to determine settlement payments.

3.1 Duke Energy Baseline SAS Code Audit

Navigant has identified several opportunities to improve the functionality of the SAS code along with making the code more readable for other support staff. <u>The following list of findings and suggestions are intended to improve functionality and consistency</u>:

Methodology and Baseline Calculations

- Navigant has found that Duke Energy is correctly conducting settlement baseline calculations in the daily baseline calculation code in accordance with the intended approach.
- During the review of calculations for seasonal capabilities (separate from daily baseline calculations), Navigant found that the forecast includes the holidays of July 4th and Labor Day, and that those holidays are treated as regular weekdays.[6] Although the impact of treating two holidays as weekdays rather than weekends would be very minimal, Navigant suggests that Duke Energy consider treating those holidays as weekends in the code.
- Weekday and weekend datasets for calculating DR capabilities are created using the "today()" function. This would cause an error in weekend calculations if the code is run on a weekend since there is a dependency of "today" being a weekday. Navigant understands that Duke Energy calculates the weekend capabilities on Fridays so there are likely no errors, however we recommend that Duke Energy consider updating the capability codes to account for day type in case the estimates are ever calculated on a weekend.

SAS Code Functionality

- The 'main' SAS script for each jurisdiction should be simplified to improve readability and consistency.
    - <u>Recommendation:</u> Move all analysis into sub-routines and update the 'main' scripts to only do the following:
        - Define global macro variables
        - Import external data
        - Call sub-routine SAS scripts

[5] The "program tracking database" refers to the documentation provided by Duke Energy outlining the reported capacity and energy values used by Duke for settlement payment.
[6] The seasonal capabilities are estimated for summer (June-September) and winter (January and February).

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- Comments and descriptions should be added to the beginning of each file and section of code to provide simplified documentation of what the code accomplishes.
    - Recommendation: Add at least a one-sentence description at the beginning of each SAS script file and at the beginning of each section of code.
- After each SAS script is run, temporary datasets and macro variables that are not used in subsequent scripts should be deleted to avoid any misuse of data from preceding analysis.
    - Recommendation: Include the "PROC DATASETS" procedure at the end of each script to delete datasets and macro variables that are no longer needed.
- Delete any code that is not being used in the analysis to improve readability and prevent errors.
    - Recommendation: Delete all unnecessary code that has been commented out of each script.

3.2 PowerShare Impacts and Findings from Navigant's Replication of EPO Calculations

This section describes Navigant's findings based on our analysis of the program tracking database and the replication of the EPO calculations that deliver the energy and demand impacts used by Duke Energy to determine settlement payments.

Navigant replicated the EPO calculations for all of the participants in the period from June through September of 2016. A comparison of Navigant's replicated calculations with the output of the EPO revealed no deviations beyond what could be expected as a result of rounding error, meaning that Duke Energy's estimates are accurate. A summary of the validation results, by option and credit type may be found in Table 3, below.

Table 3: Verification of EPO Calculations

Program Option	Credit Type	Customers	Unique Accounts	# of EPO Results Replicated[a]	Average % Absolute Error[b]
Mandatory Curtailment	Energy	93	168	663	0.00%
Mandatory Curtailment	Capacity	93	168	663	0.01%
Generator Curtailment	Energy	9	12	48	0.00%
Generator Curtailment	Capacity	9	12	48	0.01%

a. The number of calculations reproduced by Navigant for this analysis. For energy there is one credit calculated per participating account per event. For capacity there is one credit calculated per participating account per month. The period of analysis for this evaluation included four months and four curtailment events.

b. The absolute error represents the difference between Navigant's replicated settlement results and the EPO estimates used by Duke Energy. The near-zero error demonstrates that Navigant was able to replicate settlement calculations using the algorithms provided by Duke Energy.

Source: EPO Settlement Data and Navigant analysis

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This value is calculated according the EPO algorithms described above using Duke Energy's participant baselines and participant interval data. The vast majority of this was delivered by customers enrolled in the Mandatory Curtailment option. The energy reduction achieved for the July 13th event is smaller than the other events because the July 13th event lasted 2.5 hours, while the July 14th event lasted five hours and the events on July 25th and 26th each lasted six hours. The total energy impacts per event for the summer of 2016 by PowerShare option are summarized in Table 4, below.

Table 4: Summary of 2016 Event Impacts (Total Program MWh per Event)

Program Name	July 13th	July 14th	July 25th	July 26th	Total
Mandatory Curtailment	673	1,405	1,729	1,736	5,543
Generator Curtailment	18	37	44	45	144

Source: EPO Settlement Data and Navigant analysis

Total program impacts are driven by curtailment for individual meters, with a relatively small percentage having significant impacts. Seven of the 180 meters participating in 2016 accounted for approximately one third of total curtailment. Figure 1 shows each meter's average hourly event energy reduction across the summer. These are sorted in descending order, to highlight the contrast between the largest and smallest contributors in the program.

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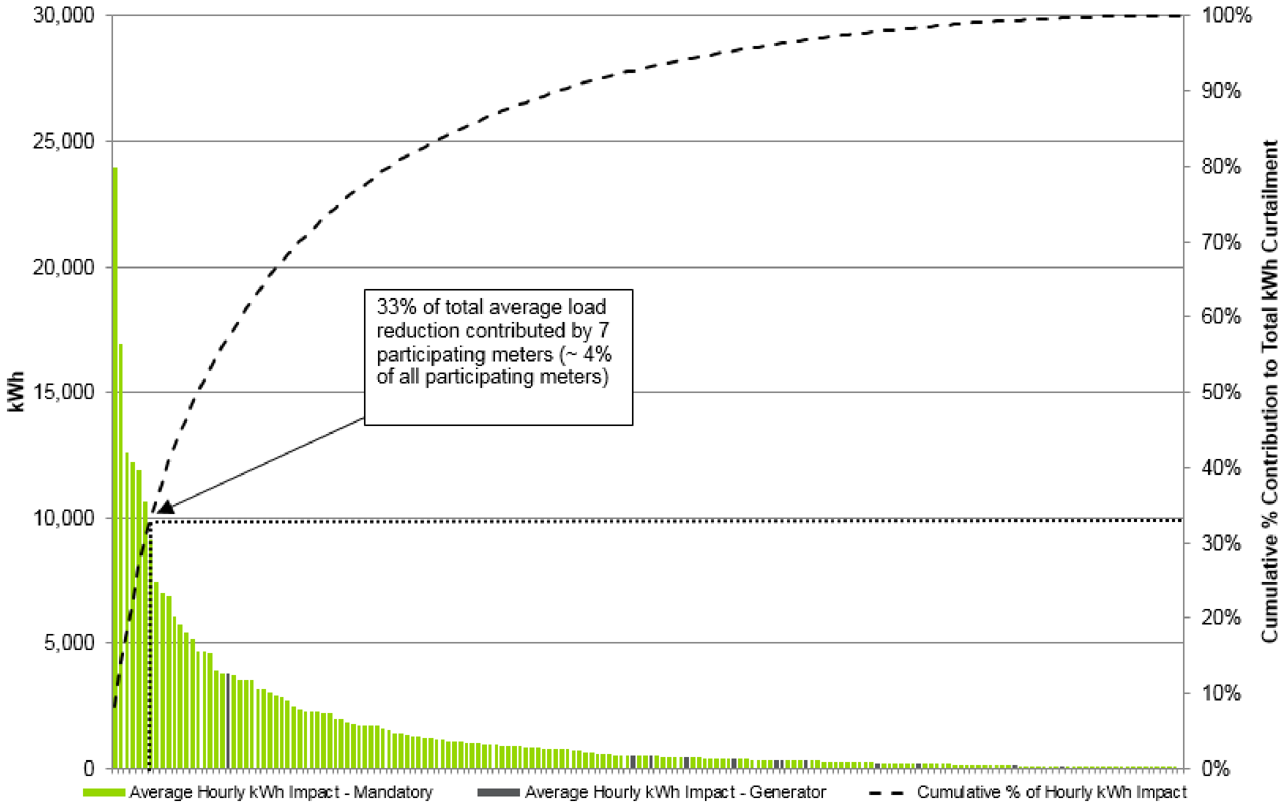
Figure 1: Average Event Curtailment by Participant



Source: EPO Settlement Data and Navigant analysis

The PowerShare Program paid out capacity credits to participants for an average monthly capacity of nearly 328 MW during the summer of 2016. This value is calculated according the EPO algorithms described above using Duke Energy's participant baselines and participant interval data. As is the case for delivered energy, the vast majority of this was delivered by customers enrolled in the Mandatory Curtailment option. The total DR capacity per month for the summer of 2016 by PowerShare option is summarized in Table 5, below.

Table 5: Total Monthly Capacity for 2016 (MW)

Program Name	June	July	August	September	Average
Mandatory Curtailment	329	302	337	312	320
Generator Curtailment	8	7	9	9	8

Source: EPO Settlement Data and Navigant analysis

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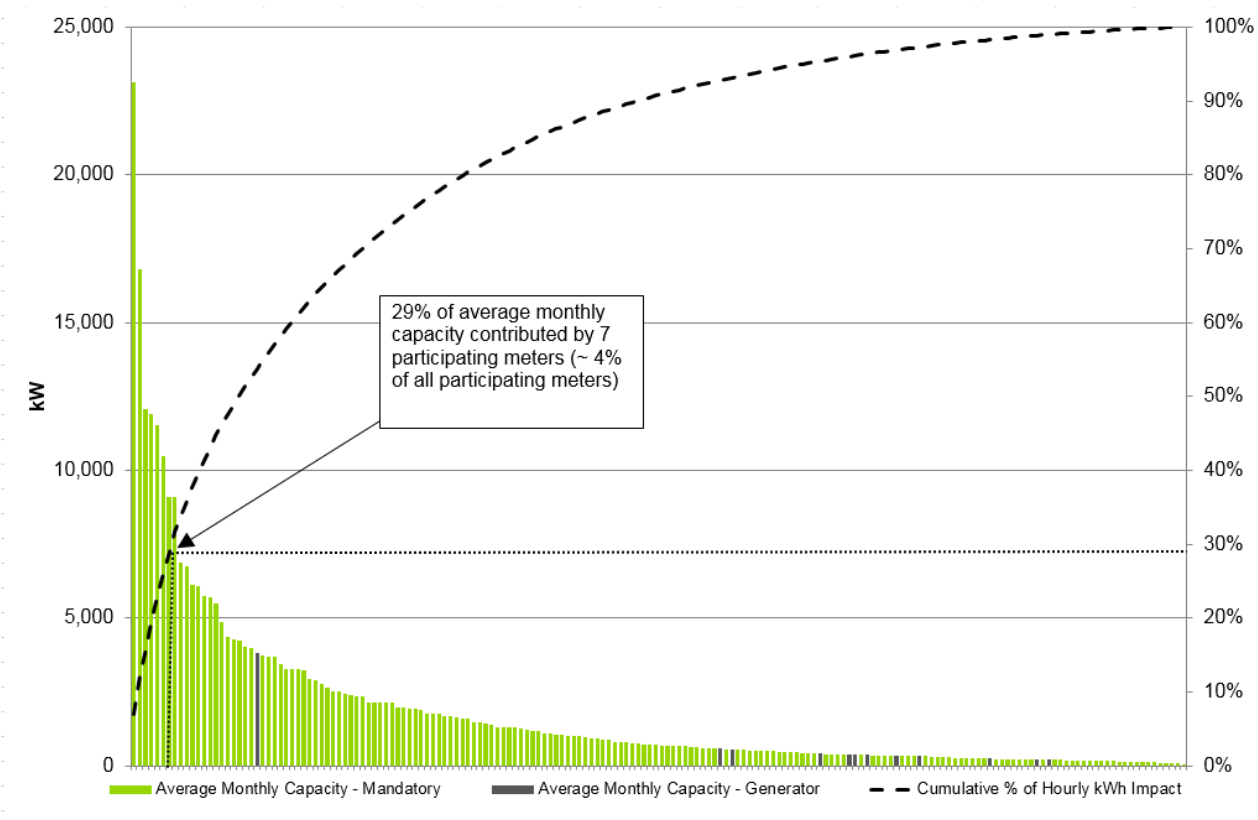
Similar to average event curtailment, average monthly capacity is driven by a small percentage of meters. The ranking of participants by their average monthly capacity is nearly identical to that of their average event reduction. Figure 2 shows that the top seven meters in terms of average monthly capacity account for 29% of total average monthly capacity. Six of the top seven meters in average monthly capacity are the same as the top seven meters in average event curtailment.

Figure 2: Average Monthly Capacity by Participant



Source: EPO Settlement Data and Navigant analysis

As suggested by the similarity of Figure 1 and Figure 2, most participants' average monthly capacity is nearly equal to their average hourly event curtailment. Figure 3 plots each participant's average monthly capacity compared to average hourly curtailment. The dotted line shows a 1:1 proportion of capacity to curtailment, and illustrates that most participants fall close to this proportion.

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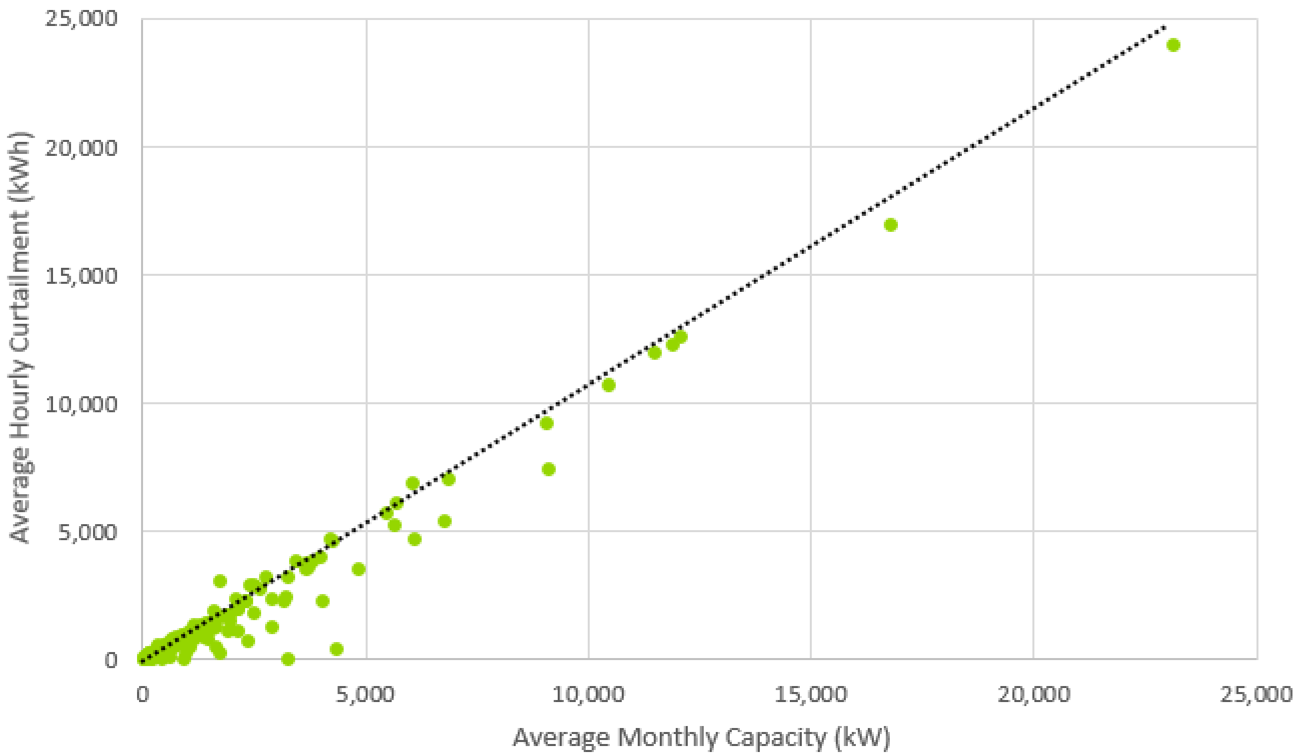
Figure 3: Capacity vs. Curtailment by Participant



Source: EPO Settlement Data and Navigant analysis

Program participation[7] was consistent throughout the summer with an average of approximately 160 customers participating in the Mandatory Curtailment option and 12 customers participating in the Generator Curtailment option. Table 6, below, provides a summary of the number of customers, by option, that participated in each event.

Table 6: Summary of Participation by Event for 2016 (Number of Participants)

Program Name	July 13th	July 14th	July 25th	July 26th	Average
Mandatory Curtailment	156	161	157	155	157
Generator Curtailment	12	12	12	12	12

Source: EPO Settlement Data and Navigant analysis

[7] For the purposes of this evaluation report, a meter is defined as having "participated" in an event when only when it delivers some energy reduction during the curtailment period.

4. CONCLUSIONS AND RECOMMENDATIONS

This section presents Navigant's key evaluation findings for the two principal evaluation objectives:

- **Duke Energy Baseline SAS Code Audit.** This sub-section presents the key findings of Navigant's audit of the Duke Energy SAS code used to estimate baseline and capability calculations.
- **Verification and Validation of Settlement Energy and Demand Calculations.** This sub-section presents the key findings of Navigant's efforts to replicate the calculation of the participant-level kWh and kW impacts used to determine settlement payments.

4.1 Duke Energy SAS Code Audit

Navigant's detailed review of Duke Energy's SAS code determined that the settlement baseline and monthly and seasonal capabilities are being calculated correctly per Duke Energy's definitions. Navigant provided a series of recommendations to Duke Energy that are meant to enhance the functionality of the code, and reduce potential for errors. Navigant recommends the following:

Methodology and Baseline Calculation Recommendations

- Update the DR capability code to take into account the day type for each day in the capability period.

SAS Code Functional Recommendations

- Move all analysis into sub-routines and update the 'main' scripts to simplify the flow of analysis
- Add at least a one sentence description at the beginning of each SAS script file and at the beginning of each section of code.
- Include the "PROC DATASETS" procedure at the end of each script to delete datasets and macro variables that are no longer needed.
- Delete all unnecessary code that has been commented out of each script.

4.2 Verification and Validation of Settlement Energy and Demand Calculations

Navigant found no major discrepancies when replicating Duke Energy's settlement calculations per the algorithms defined in Section 2.2. This finding confirms that Duke Energy's procedure for calculating impacts is functioning in accordance with the program definitions.

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APPENDIX A: DUKE BASELINE SAS PROCESS FLOW

The following outline provides a functional description of what the SAS code is doing in the Duke Energy Carolinas region. These notes are intended as documentation that can be referenced without a deep understanding of the nuances of SAS code.

<u>Duke Energy Carolinas Code:</u>

- Set date ranges for analysis
- Import line losses
- Import load data
- Import participation data
- Consolidate IS and PS datasets
- Flag weekend days and holidays in load data
- Flag event days in load data
- Data quality checks
  - Remove non-participants from data
  - Assess missing data by account
  - Identify accounts with insufficient data for forecast
  - Analyze accounts with some missing data (partial days missing vs. whole days)
  - Identify intervals with 0 load
  - Generate PDF report of data quality metrics
- Forecast capability
  - Weekday forecast
    - Select data for pro forma forecast (excludes weekends, event days, and holidays)
      - Prior 480 intervals (10 days) in Southeast (30-minute intervals)
    - Calculate average load by hour and account
    - Generate a list of the next 35 days from today's date for forecast dates
    - Merge KW values with the forecast date list
  - Weekend forecast
    - Select weekend days for forecast
      - Prior 192 intervals (4 days) in Southeast (30-minute intervals)
    - Calculate the average KW by hour and account
    - Generate a list of the next 35 days from today's date for forecast dates
    - Join average KW values to forecast dates when the day is Saturday or Sunday
  - Select the weekdays from the weekday forecast series and join to the weekend forecast
  - Produce 'slinger' (*.LSE) file using the forecast
  - Create hourly forecast dataset to estimate and report capability
  - Join account IDs to hourly forecast data for weekdays
  - Calculate capability based on compliance plan
    - Remove accounts with insufficient data
  - Output summarized capability for parent accounts
  - Summarize capability by program, state, and hour
  - Adjust capability for line losses
  - Count the number of participants by program and state
  - Repeat preceding steps, but using weekend forecast
  - Calculate generator capability with line loss adjustments to the Firm Fixed KW value
  - Summarize generators by state with participant counts and KW
  - Generate PDF reports with participant counts, KW capability, and data deficiency summaries for weekdays and weekends